Process and device for the detection of hydrocarbons in a gas

5   The invention relates to the field of the detection of hydrocarbons other than methane in a gas comprising or essentially comprising oxygen and in particular a gas comprising at least 95% of oxygen with impurities, in particular hydrocarbon impurities, the

10   said hydrocarbon impurities being, for example, present at less than 200 ppm.

The invention also relates to units for the production of gases from the air. This is because the presence of nonmethane hydrocarbons in the liquid

15   oxygen bath of the evaporators of these production units leads to a risk of explosion when certain concentration limits are exceeded. These limits are defined in the operating instructions for the production units.

20   The techniques currently used to identify and detect these hydrocarbons are, on the one hand, chromatography and, on the other hand, infrared spectrometry (FTIR).

Chromatography is a technique which has been

25   used for a very long time. It is sequential and only allows the detection and measurement of a few preselected hydrocarbons. The capital investment and the maintenance costs of the chromatograph are high.

Infrared spectrometry (FTIR) is a technique

30   which, although more effective than chromatography, is not completely comprehensive, as it requires an examination of the spectrum in order to search for an impurity which would not have been preselected. In addition, the equipment requires a high capital

35   investment.

The problem is thus posed of finding a novel method and a novel device which make possible continuous measurement and continuous detection of

hydrocarbons other than methane in a gas essentially comprising oxygen.

The problem is also posed of finding a method and a device which are simpler to employ and less costly than the prior techniques and devices.

The problem is also posed of finding a method and a device which make possible continuous measurement and continuous detection of hydrocarbons other than methane in a gas essentially comprising oxygen, the said hydrocarbons other than methane being present, with respect to methane, in a proportion of the order of a few percent.

The problem is also posed of ensuring the safety of units for the production of gases from the air, comprising an evaporator, by the continuous comprehensive detection of nonmethane gaseous hydro-carbons at a concentration of a few ppm (for example: less than 5 ppm) in the oxygen of the evaporator, which can itself comprise methane, for example at approximately 50 ppm.

STATEMENT OF THE INVENTION

A subject-matter of the invention is first of all a process for the detection of hydrocarbons other than methane in oxygen or in a gas comprising or essentially comprising oxygen (the oxygen additionally being mixed with methane and the said hydrocarbons other than methane), the said process comprising:

- a stage of detection of the combined hydrocarbons in the said oxygen or in the said gas, providing a first value for the combined hydrocarbons,

- a stage of combustion of the hydrocarbons other than methane,

- a stage of detection of methane in the said oxygen or in the said gas, providing a second value, preferably followed by,

- a stage of calculation of the amount of hydrocarbons other than methane by the difference between the first value and the second value.

Such a process makes it possible to carry out a continuous measurement of the hydrocarbons other than methane.

The stages of detection can be carried out by a flame ionization detector. A detection system is thus produced which is simple to use, which operates continuously, which is accurate, which is less expensive and which requires less maintenance than the known systems.

According to one embodiment, the hydrocarbons other than methane are incinerated in a catalyst.

In addition, hydrogen can be mixed with the gas to be analysed, so that the mixture exhibits an $H_2:O_2$ ratio close to or of the same order as the $H_2:O_2$ ratio in the air.

The temperature of the catalyst is preferably such that less than 5% of the methane present in the gas is incinerated.

The invention also relates to a process for the detection of hydrocarbons other than methane in a liquid oxygen bath of an evaporator of a unit for the production of gases from the air, comprising:

- a withdrawal of a sample of liquid oxygen from the said bath,

- an evaporation of the said liquid oxygen, producing an evaporated gas,

- a process for the detection of hydrocarbons other than methane in the said evaporated gas, as described above.

The withdrawal of the sample is preferably carried out using a pipe of a pump for raising liquid or over a sampler of lift type, which makes it possible to sample the gas rapidly and thus to analyse at each instant a fairly representative sample of the mixture to be analysed at the same instant.

The invention also relates to a device for the detection of hydrocarbons other than methane in a gas predominantly or essentially comprising oxygen, as well as methane and the said hydrocarbons other than

methane, which is especially suitable for the implementation of a process as described above, the said device comprising:

- means for the detection of the combined hydrocarbons in the said gas, providing a first value for the combined hydrocarbons,

- means for the combustion of the hydrocarbons other than methane,

- means for the detection of methane, and preferably,

- means for, or especially programmed for, the calculation of the amount of hydrocarbons other than methane by the difference between the first value and the second value.

The invention also relates to a device for the detection of hydrocarbons other than methane in a liquid oxygen bath of an evaporator of a unit for the manufacture of gases from the air, comprising:

- means for the withdrawal of a sample of liquid oxygen from the said bath,

- means for the evaporation of the said liquid oxygen, producing an evaporated gas,

- a detection device as described above.

Means can additionally be provided for triggering an alarm when the concentration or the level of hydrocarbons other than methane in the said evaporated gas exceeds a certain limit value.

BRIEF DESCRIPTION OF THE FIGURES

The characteristics and advantages of the invention will become more clearly apparent in the light of the description which will follow. This description relates to implementational examples, given by way of explanation and without implied limitation, with reference to appended drawings, in which:

- Figure 1 represents an implementational example of the invention,

- Figure 2 represents the structure of a detector which can be used in the context of the present invention,

- Figure 3 represents a test of response of nonmethane hydrocarbons in oxygen,

- Figures 4A to 6B represent various trials carried out on mixtures of oxygen and of hydrocarbon,

- Figures 7 and 8 represent a device for the withdrawal of a sample and for analysis from a liquid oxygen bath.

DETAILED DESCRIPTION OF EMBODIMENTS OF THE INVENTION

An implementational example of the invention is given in Figure 1.

In this figure, reference 2 denotes an inlet of a gas to be measured which is composed of or which comprises oxygen or essentially oxygen and which includes hydrocarbon impurities, for example at less than approximately 200 ppm, for example 100 ppm or 50 ppm or at a level of the order of a few tens of ppm.

The hydrocarbon impurities may include, on the one hand, methane and, on the other hand, nonmethane gaseous hydrocarbons. According to one example, methane is present at a level of approximately 50 ppm and the nonmethane gaseous hydrocarbons are present at a level of the order of 5 ppm.

Other impurities can additionally be present, in particular nitrogen or argon, but the gas essentially comprises oxygen at least 95 %, preferably at least 99% or 99.5%.

In the case where only hydrocarbons are present, at a level of 200 ppm, the gas comprises 99.98% of oxygen.

Reference 10 denotes a system for analysis according to the invention.

The gas to be measured can, via a valve 4, either be conveyed over a catalyst 6, which makes it possible to incinerate the nonmethane gaseous hydro-

carbons (HCnM, or measurement in CH_4 mode), and then over a detector 8, or be conveyed directly over the detector 8. In the second case, all the hydrocarbons are detected (total hydrocarbons, or HCT, or measurement in HCT mode) and the detector emits a signal ST representative of the total amount of hydrocarbons. In the first case, only methane arrives at the detector and the latter emits a signal S4 representative of the total amount of methane. Processing of the signals, for example using numeric means for signal processing and for calculation 7, subsequently makes it possible, by ST-S4 subtraction, to deduce a measurement for the combined nonmethane gaseous hydrocarbons.

A catalyst which can be used for the combustion of the nonmethane gaseous hydrocarbons can be:

- a metal oxide or a mixture of metal oxides which are deposited on an absorbent of zeolite type (alumina or other type, and the like). The metal oxide can be: MnO_2 (manganese oxide), CuO and Cu_2O (copper oxide), ZrO_2 (zirconium oxide), and the like.

- a precious metal or a mixture of precious metals which are deposited on an adsorbent of zeolite type (alumina or other type, and the like). The metal can be, for example: Pt (platinum) or Ni (nickel) or Rh (rhodium).

Use may also be made of Pt or Ni gauze, sponge or wire. Another example of a catalyst is carulite, with the composition: 60% to 75% of MnO_2, from 11% to 14% of CuO, and from 15% to 16% of Al_2O_3. Yet another example of a catalyst is hopcalite, with the composition 33-44% MnO_2 and 22-36% CuO (the remainder being a binder).

The detector 8 is, for example, a flame ionization detector. In this case, hydrogen is additionally mixed with the gas to be analysed at the inlet of the detector 8. Air is injected above the flame of hydrogen and of gas to be analysed, this air

serving to remove the water vapour formed by the combustion.

An example of such a detector is that sold by Environnement S.A. (111, Bd Robespierre, 78300 POISSY, FRANCE) under the reference HC51M.

The hydrogen flow rate is preferably such that the composition of the hydrogen-gas to be analysed (oxygen) mixture is between 10% and 40% or is close to or is of the order of the O_2-H_2 ratio in the air (approximately 30%). This makes it possible for the detector to be able to operate with an oxygen sample flow rate while obtaining the same detection sensitivity as for tests carried out on air.

An increase in the hydrogen flow rate doubtless also has the effect of modifying the shape of the flame where the ionic current produced by the combustion of the HCnMs is collected. The collecting electrode for this current is positioned above the flame and the proportion of ions collected may be different according to the shape of the flame.

By way of example, the hydrogen flow rate is approximately 130 ml/min (in contrast to 40 ml/min for use in air), the sample (oxygen) and air (bleed or removal of the water vapour) flow rates being 80 ml/min and 400 ml/min respectively.

The temperature of the catalyst 6 is preferably chosen such that as little as possible of CH_4 is incinerated. This is because, in the case of carulite, for a temperature of approximately 210°C, it could be observed that a not insignificant proportion of CH_4 was incinerated. In point of fact, the calculation of the concentration of the HCnMs consists in knowing the difference between the measurement in HCT mode (when the sample passes directly into the detector) and the measurement in CH_4 mode (when the sample passes into the catalyst before going into the detector). The concentration of HCnM is then significantly increased.

In order to reduce the combustion of methane in the catalyst, the temperature was adjusted in two stages (case of carulite):

1. Regulation of the temperature at 163°C. The analysis of a mixture comprising 10 ppm of CH_4 + 1 ppm of C_2H_6 in oxygen functions well but the analysis of a mixture comprising 52.2 ppm of C_2H_6 + 52.5 ppm of CH_4 in oxygen shows that approximately 10% of C_2H_6 is not incinerated, a proportion which cannot be evaluated with accuracy over a C_2H_6 content of 1 ppm.

2. Regulation of the temperature at 182°C. The results are satisfactory with regard to the 2 preceding mixtures and with regard to a mixture which does not comprise CH_4 but only 8 ppm of C_2H_6 in oxygen, for which all the C_2H_6 is incinerated.

The regulation of the operating temperature of the converter for nonmethane hydrocarbons, for example between 160°C and 190°C, thus makes it possible not to lose methane (or to lose at most a few % thereof, for example at most 3% or 5%) while converting the nonmethane hydrocarbons (HCnMs) of the sample of oxygen to be analysed.

Figure 2 represents a detailed example of the detection system 10 with a detector, of HC51M type already mentioned above, as used in the context of the present invention. This system employs a flame ionization detector 8.

As already explained above, hydrogen and air are introduced into this detector via routes 12 and 14 respectively.

Oxygen, at a pressure of approximately one bar, is introduced via route 16, in order to zero the device.

The oxygen to be analysed is introduced via route 18, route 21 making possible the introduction of a standard gas at atmospheric pressure.

Route 25 makes it possible to bleed off an excess of samples introduced into the circuit.

In a more detailed way, route 12 successively comprises a regulator 37, at the terminals of which is positioned an ignition loop 32.

Route 14 successively comprises a purifier (not represented) and a regulator 41.

Route 16 comprises a purifier (not represented) and a regulator 31 and is connected to a three-way electrically operated valve 24.

The sample of gas to be analysed, a valve 20 and a pump 22 also arrive via this electrically operated valve 24. An excess of sample is bled off via a regulator 23.

A three-way valve 26 makes it possible to convey a gas to be analysed either directly to the analyser 30 (the reference 28 denotes a charge-balancing capillary) or to a catalyst 6 in order to incinerate the nonmethane hydrocarbons. The reference 33 denotes a variable capillary which makes it possible to regulate the flow rate at the inlet of the detector 30. The latter delivers signals ST and S4, from which a calculator can calculate, by subtraction, a signal representative of the amount of nonmethane hydrocarbons.

Figure 3 represents a test of response of C_n (n = 2, 3 or 4) nonmethane hydrocarbons (HCnMs) in oxygen in the presence of 10 ppm of CH_4. The trials relate to:

- 10 ppm of CH_4 in O_2
- 10 ppm of CH_4 + 1 ppm of C_2H_6 in O_2
- 10 ppm of CH_4 + 1.1 ppm of C_2H_4 in O_2
- 10 ppm of CH_4 + 1.2 ppm of C_2H_2 in O_2
- 10 ppm of CH_4 + 1.1 ppm of C_3H_6 in O_2
- 10 ppm of CH_4 + 1.1 ppm of C_3H_8 in O_2
- 10 ppm of CH_4 + 1 ppm of C_4H_{10} in O_2

The device used is of the type sold by Environnement S.A. (111, Bd Robespierre, 78300 POISSY, FRANCE) under the reference HC51M, with the following operating conditions:

- catalyst temperature: 182°C,

- hydrogen flow rate: approximately 130 ml/min,
- sample flow rate: 80 ml/min,
- oxidant air flow rate: 400 ml/min,
- catalyst: carulite (composition indicated
5   above).

Curve I gives the amount of HCnM, curve II gives the amount of CH_4 and curve III gives the total amount of hydrocarbons.

These trials indicate that the response of the
10 flame ionization detector is indeed proportional to the number of carbon atoms in the C_nH_m to be measured, except for C_2H_2 (C_2H_2 has a better response). The device is capable of detecting less than 1 ppm of C_nH_m as CH_4 equivalent in oxygen comprising 10 ppm of CH_4. That is,
15 less than 0.5 ppm of C_2, less than 0.3 ppm of C_3 and less than 0.25 ppm of C_4.

This test gives similar or identical results for sensitivity to a test carried out for measurements of C_nH_m in air (but with different conditions: catalyst
20 temperature of 210°C, hydrogen flow rate of 40 ml/min, sample flow rate of 80 ml/min, oxidant air flow rate of 400 ml/min).

In Figures 4A to 6B, curve I represents the change in the concentration of HCnM, as CH_4 equivalent,
25 and curve II represents the change in the concentration of HCT, also measured as CH_4 equivalent.

Figures 4A and 4B represent the response of the dilution of an HCnM mixture comprising 10.7 ppm of C_2H_4 in oxygen possessing 52.9 ppm of CH_4 with oxygen
30 possessing 52.7 ppm of CH_4 (this makes it possible to gradually dilute the HCnM mixture and thus to vary the concentration of C_2H_4 while retaining a constant concentration of CH_4). This trial, and in particular curve I, shows that it is possible to estimate an HCnM
35 detection threshold below 5 ppm as CH_4 equivalent, i.e. approximately less than 2 to 3 ppm of C_2H_4.

Figures 5A and 5B represent the response of the dilution of an HCnM mixture comprising 5.3 ppm C_3H_8 in oxygen possessing 49.7 ppm of CH_4 with oxygen

possessing 52.7 ppm of CH_4. This trial shows, as above, an HCnM detection at less than 5 ppm as CH_4 equivalent, i.e. less than 2 ppm as C_3H_8.

Figures 6A and 6B represent the response of the dilution of an HCnM mixture comprising 52.2 ppm of C_2H_6 in oxygen possessing 52.5 ppm of CH_4 with an O_2 mixture possessing 52.7 ppm of CH_4. This trial confirms the preceding results and makes it possible to verify the linearity of the response of the device from 0 to 160 ppm as CH_4 equivalent.

In the 3 examples given above, curve I shows that it is possible, according to the invention, to detect less than 5 ppm of nonmethane hydrocarbons (as CH_4 equivalent), in approximately 50 ppm of methane.

Following these trials, the drift of the device with regard to the measurement carried out on oxygen from the zero circuit (oxygen circulating via route 16 of the diagram in Figure 2) was measured. Over approximately twenty hours, the HCnM drift is less than 0.1 ppm.

It should be noted that impurities can poison the catalyst when it is used directly on ambient air as gas to be analysed. In contrast, such impurities do not exist when oxygen is used as gas to be analysed, as in the context of the present invention (and in particular oxygen resulting from the unit for the production of gases from the air). The use according to the present invention thus makes it possible to increase the duration of use of the catalysts.

According to one result example, the invention makes it possible to detect less than 5 ppm of hydrocarbons, as methane equivalent, in oxygen comprising approximately 50 ppm of methane (see Figures 4A to 6B commented upon above), i.e. less than 2 to 3 ppm of C_2 nonmethane hydrocarbons, less than 2 ppm of C_3 nonmethane hydrocarbons and less than 1 ppm of C_4 nonmethane hydrocarbons.

According to another result example, the invention makes it possible to detect less than 1 ppm,

as CH_4 equivalent, of HCnM (of C_2 and/or C_3 and/or C_4 type), in particular in oxygen comprising 10 ppm of CH_4 (see Figure 3 and corresponding commentary above), i.e. less than 0.5 ppm of C_2H_6, 0.3 ppm of C_3H_8 and 0.25 ppm of C_4H_{10}.

According to yet another result example, the invention makes it possible to detect less than 5 ppm, as CH_4 equivalent, of HCnM (C_2 and/or C_3), in particular in oxygen comprising 50 ppm of CH_4 (see Figures 4A-6B commented upon above), i.e. less than 2 to 3 ppm of C_2 and less than 2 ppm of C_3.

A device and a process as described above can be used in a unit for the production of gases from the air. An example of such a use is illustrated in Figures 7 and 8.

In these figures, the reference 60 denotes a liquid oxygen tank comprising a liquid oxygen bath 63. A sample of liquid oxygen is withdrawn from this bath via a pipe of a pump 70 for raising liquid (Figure 8) or over a sampler 61 of lift type (Figure 7). This second solution comprises a circulation of liquid towards a small tank 62 situated close to the wall of the tank 60. Complete evaporation of the liquid subsequently takes place in an evaporator composed of a capillary and an atmospheric exchanger 64, 72. The constituents of the gas mixture to be analysed are subsequently homogenized using a mixer 66, 74. The flow rate of the gas sample is, for example, approximately 0.5 to 1 Sm^3/h. These two devices make it possible to rapidly sample and convey, to the analyser 10 for hydrocarbons, a gas sample representative of the liquid in the bath 63 of the production unit. They also make it possible to withdraw a liquid which is often replaced: this is because the composition of the liquid present in the tank 60, and in particular the impurities which are to be measured with the device according to the invention, can vary over time. It is thus preferable to have in the withdrawal circuit, at any instant, a sample which represents, in as exact a

manner as possible, the composition, at the same instant, of the liquid in the tank 60. This is rendered possible here by the use of means such as the pump 70 for raising liquid or the sampler 61 of lift type.

A system and a process according to the invention, such as, for example, described above in connection with Figures 1 or 2 or 7 or 8, make it possible to monitor the level of nonmethane hydrocarbons in oxygen and in particular in a liquid oxygen bath, such as the bath of the evaporators of units for the production of gases from the air. When the level or the concentration of nonmethane hydrocarbons exceeds a certain limit value (which, as is understood from Figures 3 to 6B, can be of the order of a few ppm, as methane equivalent, for example 5 ppm as methane equivalent or less, for example even 1 ppm as methane equivalent), an alarm can be triggered and a risk of explosion is thus avoided or reduced. The limit values can, for example, be defined in the operating instructions of the production units or can be stored in memory in the processing unit 7 (see Figure 1) which carries out the measured values-limit values comparison.

In the case of a unit for the production of gases from the air, the continuous measurements of the combined hydrocarbons, of methane and of the nonmethane hydrocarbons make it possible, in the event of exceeding preset concentrations of nonmethane hydrocarbons, to trigger procedures for rendering the production unit safe. For example, depending upon the levels of the alarms, action may be taken with respect to the operation of the purification of the incoming air and/or with respect to the operation of the production and/or shutdown of the production.